Second Harmonic Generation by $BaTiO_3$ microparticles in porous materials

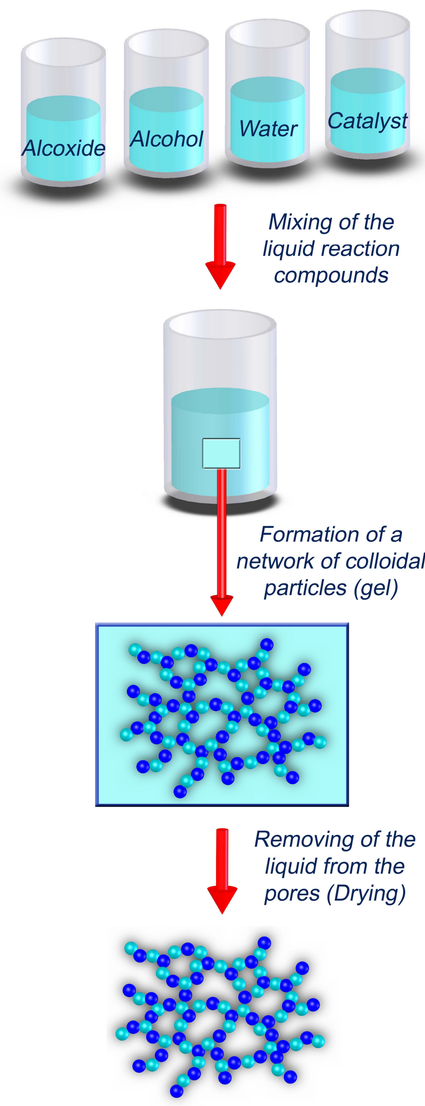
S. Lisinski, D. Schaniel, Th. Woike, L. Ratke, M. Imlau
DLR, Institut für Materialphysik im Weltraum, Linder Höhe, 51147 Köln, Germany
Universität zu Köln, I. Physikalisches Institut,, Zülpicher Str. 49b, 50937 Köln, Germany
Universität Osnabrück, Fachbereich Physik, 49069 Osnabrück, Germany

Motivation

Preparation of random medias with nonlinear optical properties
- cheap nonlinear optical (NLO) materials
- easy synthesis of NLO materials: Sol-Gel method
- novel applications
- use of disordered materials for NLO applications, e.g., random laser, frequency conversion

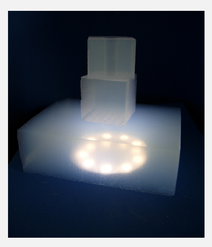
Aim: Embedding of NLO materials (powder) in aerogel/xerogel matrix

Synthesis



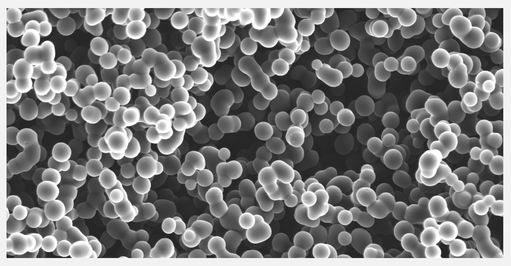
Procedure

- Synthesis of silica and titana aerogels/xerogels via sol-gel method
- Embedding of NLO particles during liquid phase
- Homogeneous distribution of particles in aerogel/xerogel matrix
- Measuring of SHG



Def.: Aerogels are supercritical dried gels (90-99% pores) and xerogels are dried under ambient conditions (<50% pores)

Properties of aerogels and xerogels:
- 3D nano-network of colloidal particles (SiO_2 or TiO_2)
- Transparent in the range 280-2700 nm
- refractive index tunable in the range 1.2-2.1

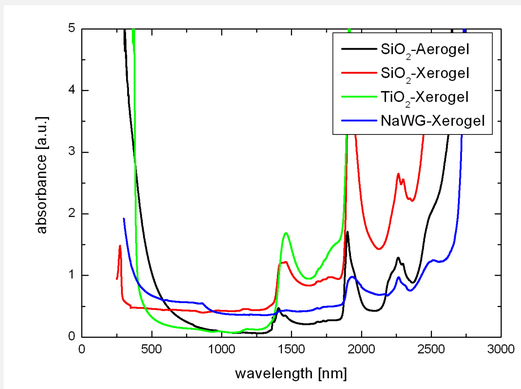


Results

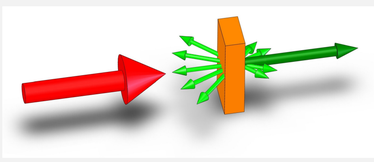
Transparency range of dry gels:

SiO_2 aerogel: 330-2650nm
SiO_2 xerogel: 280-2460nm
TiO_2 xerogel: 390-1880nm
NaWG xerogel: 350-2680nm

NaWG=Sodium waterglass

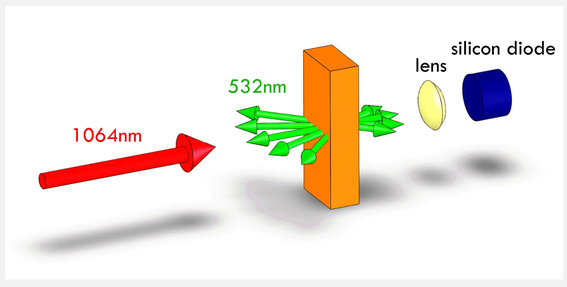


Refractive index matching

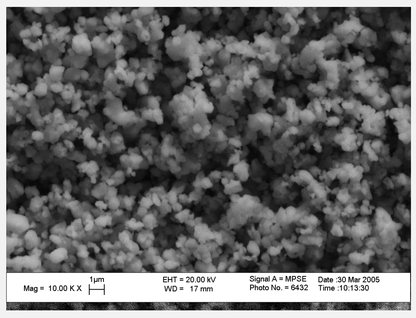


Mixed SiO_2-TiO_2 xerogels have an adjustable refractive index in the range 1.2-2.1 and can thus be matched to the index of the particles, such that $n_{aerogel/xerogel}=n_{powder}$

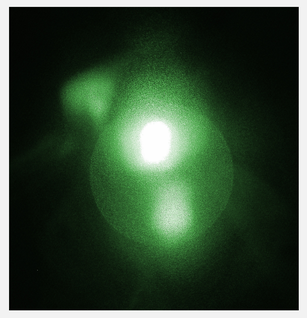
For **second harmonic generation** we used the 1064nm pulse of a Nd:YAG laser (FHW=6ns, Input energy=0-80mJ). The SHG-effect is measured for $BaTiO_3$ particles with an average particle size of 1µm in a silica xerogel based on sodium waterglass



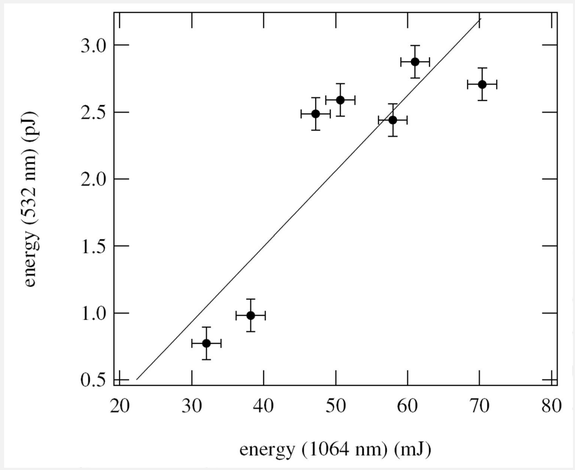
Scanning electron microscope picture of the $BaTiO_3$ particles with an average particle size of 1µm



The generated green light scatters in all directions, because of the random particle polarisation



Linear increase of SH intensity with incident intensity
Nd-YAG pump laser:
- incident energy 0-80mJ
- full width at half-maximum 6ns
- incident wavelength 1064nm



Concentration dependence, i.e. there is an "optimal" number density *n* of $BaTiO_3$ particles in the xerogel matrix

$$I_{\mathrm{SHG}} \sim n e^{-n\alpha} = n e^{-n\sigma d}$$

α: scattering coefficient
σ: cross section
d: thickness of sample